AD-A088 842 ARMY ELECTRONICS RESEARCH AND DEVELOPMENT COMMAND WS--ETC F/G 20/6
EVALUATION OF SPECIALIZED PHOTOACOUSTIC ABSORPTION CHAMBERS FOR--ETC(U)
AUG 80 B Z SOJKA, K O WHITE
UNCLASSIFIED ERADCOM/ASL-TR-0063 NL

1 OF 1
AD
A088842

END
DATE
FILMED
10-80
DTIC

(12) LEVEL II

AD

Reports Control Symbol
OSD-1366

ASL-TR-0063

AD A088842

EVALUATION OF SPECIALIZED PHOTOACOUSTIC ABSORPTION CHAMBERS FOR NEAR-MILLIMETER WAVE (NMMW) PROPAGATION MEASUREMENTS

AUGUST 1980

By

Brian Z. Sojka*
and
Kenneth O. White

*Now with
Hewlett-Packard

Approved for public release; distribution unlimited

US Army Electronics Research and Development Command
ATMOSPHERIC SCIENCES LABORATORY
White Sands Missile Range, NM 88002

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government indorsement or approval of commercial products or services referenced herein.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

ERRATA SHEET

for ASL-TR-0063

EVALUATION OF SPECIALIZED PHOTOACOUSTIC ABSORPTION CHAMBERS
FOR NEAR-MILLIMETER WAVE (NMMW) PROPAGATION MEASUREMENTS

Change figure captions to read as follows:

Page 13 Figure 2. Experimental arrangement used to test internally reflecting, spherically resonant absorption chambers.

Page 15 Figure 4. Machined aluminum enclosure.

Page 21 Figure 11. Differential type spectrophone using two electret detectors.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: 14 ERADCOM/ ASL-TR-0063	2. GOVT ACCESSION NO.: AD-A088842	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): 6 EVALUATION OF SPECIALIZED PHOTOACOUSTIC ABSORPTION ~~CELL~~ CHAMBERS FOR NEAR-MILLIMETER WAVE (NMMW) PROPAGATION MEASUREMENTS.		5. TYPE OF REPORT & PERIOD COVERED: 9 R&D Technical Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): 10 Brian Z. Sojka, Kenneth O. White		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Atmospheric Sciences Laboratory, White Sands Missile Range, NM 88002		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 16 DA Task No. 1T161101A91A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Electronics Research and Development Command, Adelphi, MD 20783	11	12. REPORT DATE: August 1980
		13. NUMBER OF PAGES: 36 12 38
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report): UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Absorption
Photoacoustic
Propagation
Near-millimeter

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Preliminary studies have been conducted to determine the feasibility of using spherical geometry photoacoustic absorption chambers at near-millimeter wavelengths (NMMW). New spherical geometry photoacoustic absorption chambers were used in a parallel experimental arrangement to the ongoing (FY 79) NMMW program. Absorption sensitivity, NMMW laser beam handling characteristics, pressure dependence, and temperature effects of the system were evaluated to determine the usefulness and applicability of these new designs for use at

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

410663 SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (cont)

NMMW. Electret microphones were acquired, and testing was done by using these microphones as detectors in specialized spherical geometry and more conventional design photoacoustic absorption chambers. Results from this study show that numerous problems exist in using the spherical geometry photoacoustic absorption chamber design. The combination of resonant frequency temperature dependence, unstable mechanical chopping, high-Q narrow-bandwidth characteristics, and excessive noise sensitivities have limited the absorption sensitivities obtainable. Electret microphone testing and evaluation have led to the design and construction of several conventional, single-pass type, photoacoustic absorption chambers.

CONTENTS

LIST OF FIGURES

BACKGROUND/INTRODUCTION

Millimeter wavelengths will apparently play an important role in future military electro-optical (EO) systems. One of the major known attenuators at millimeter wavelengths is atmospheric water vapor. At present several important features of water vapor absorption in the millimeter spectral region are not well understood and require further investigation. These features include: absorption line shape, temperature dependence, pressure dependence, foreign broadening, and the existence of "continuum" type or "cluster" type absorption. Special absorption chambers are required to perform these measurements due to the spatial profile characteristics of the far infrared (FIR) beam emitted from the near-millimeter laser source and its extremely low output powers.

A need thus exists for a device which will enable gaseous absorption measurements to be made at near-millimeter wavelengths (NMMW). Recently proposed and partially developed photoacoustic absorption chambers[1] appear to have features which would be ideal for the measurement of gaseous absorption coefficients at NMMW.

The Atmospheric Sciences Laboratory (ASL) undertook further development, evaluation, and testing of these specialized photoacoustic absorption chambers for NMMW propagation measurements to determine absorption sensitivity, pressure and temperature dependence, NMMW laser beam handling characteristics, and overall suitability for use in measuring gaseous absorption coefficients using low-power, NMMW laser sources.

This need prompted an independent laboratory in-house research (ILIR) effort to study the feasibility of using internally reflecting, spherically resonant, photoacoustic type absorption chambers for measuring gaseous absorption coefficients at NMMW.

This report presents the findings from the ILIR investigation into the use of spherically resonant, photoacoustic absorption chambers at NMMW and the use of transducer electret type detectors in these and other photoacoustic chamber designs.

EXPERIMENTAL APPROACH AND EQUIPMENT SETUP

Most photoacoustic absorption chambers (spectrophones) use a cylindrical design wherein the electromagnetic energy propagates through the test medium only once.[2] These single-pass, short path length chambers require moderate to high energy levels and well controlled beam geometries due to limited clearances dictated by chamber designs. Such considerations along with present

---

[1]Dr. Stewart A. Schleusener, Department of Electrical and Computer Engineering, New Mexico State University, Las Cruces, NM 88003

[2]Charles Bruce, 1976, Development of Spectrophones for CW and Pulsed Radiation Sources, ECOM-5802, Atmospheric Sciences Laboratory, US Army Electronics Command, White Sands Missile Range, NM 88002

sensor designs usually result in somewhat delicate and unmovable systems. A possible approach to avoiding such limitations seems to be that of dumping all of the electromagnetic source energy into an internally reflecting, spherically resonant enclosure (figure 1). In effect, the electromagnetic energy reflects numerous times from the walls until dying out. An immediate advantage of such an approach is that the effective path length is increased, thereby leading to increased sensitivity. Electromagnetic energy with a variety of beam shapes and divergence magnitudes can be effectively captured with only a minimal amount being lost back through the input window. In addition, by using sources with low-power outputs, thermal inertia effects are small; thus the energy absorbed by the walls contributes very little to the overall noise level.

The experimental arrangement used to conduct tests on the internally reflecting, spherically resonant absorption chamber is shown in figure 2. The cw CO_2 pump laser was an Advanced Kinetics MIRL-50 with typical output power ranging from 25 to 35 watts. The waveguide type NMMW laser cavity design used has been fully described in a previous publication.[3]

Data collection and recording apparatus consisted of a Princeton Applied Research (PAR) model 113 linear amplifier and PAR 128A lock-in amplifier for monitoring the phototacoustic absorption chamber signal; a second PAR 128A lock-in amplifier was used to monitor the laser output detector signal. The detector used was a Molectron pyroelectric model P3-01. Beam splitter material was quartz. A Scientech power meter was used to determine actual NMMW output power by insertion into the laser beam just in front of the sphere.

Two different internally reflecting, spherically resonant enclosures were used. One sphere was a 6-inch I. D. spun aluminum enclosure with a wall thickness of 1/32 inch and a gold coated reflective surface (figure 3). The second sphere was a 6-inch I. D. machined aluminum enclosure with a wall thickness of 3/32 inch (figure 4). The inside surface of this sphere was highly polished with kerosene and crocus cloth.

Each of the spheres was made into a photoacoustic absorption chamber by the placement of miniature transducer electret microphones through the walls of the sphere in such a manner as to be nearly flush with the inside surface. Microphones used were commercially available model CA-1833 electret type detectors manufactured by Knowles Electronics, Franklin Park, Illinois (figure 5). The machined aluminum sphere had four of these detectors tetrahedrally mounted just forward of the spheres equator (figure 3). Only one of these detectors was mounted on the spun aluminum sphere (figure 4). Each sphere had a 5/8-inch aperture with a 1-mm thick quartz window.

The output beam from the NMMW laser cavity was brought up to the input window of the spherical chamber by means of a 7/16-inch I. D. copper waveguide. Upon leaving the waveguide the NMMW beam would pass through the quartz input window--diverging at a rate such that the beam's cross-sectional area would double after traveling a distance of only 8 inches.

---

[3]B. L. Bean and S. Perkowitz, 1976, "Far Infrared Transmission Measurements with an Optical Pumped FIR Laser," Appl Opt, 15:2617-2618

EXPERIMENTAL PROCEDURES AND RESULTS

To determine the usefulness and applicability of using a resonant, spherical photoacoustic absorption chamber in the NMMW region, numerous questions must be answered. A careful investigation to determine absorption sensitivity, signal-to-noise ratios, pressure dependence, and temperature effects had to be performed.

The first step was to construct, clean, leak check, and evacuate each sphere to assure that each was contaminant free.

An audio source was used to determine the fundamental resonant frequency of each of the spheres. By using an audio oscillator, speaker, frequency counter, and oscilloscope the spheres could be driven into resonance. This procedure was first done for the machined aluminum sphere under conditions of vacuum and then with 650 torr of N_2. At an ambient temperature of 22.4°C, the resonance frequencies were 1936 Hz and 1926 Hz with ±2 Hz bandwidth, respectively. Each sphere had high-Q characteristics. Signals from the electrets were observed under these conditions and were comparable in magnitude. At this time the resonant frequency of the sphere varied greatly when subjected to even small temperature changes. A temperature change of as little as 1°C could shift the sphere's resonant frequency by as much as 15 to 30 Hz.

The NMMW laser frequency chosen was 17.5 cm^{-1} which corresponds to a wavelength of 570.5μm. The pumped medium producing this wavelength was a spectraphotometric grade of methyl alcohol (CH_3OH).[4] The CO_2 laser pumping line was 9P(16). The NMMW frequency of 17.5 cm^{-1} was chosen because of its relatively low H_2O absorption (10^{-2} dB/km attenuation). Near-millimeter laser power at this frequency was typically 0.2 mW.

Initial noise level measurements were made with the machined aluminum photoacoustic sphere at the NMMW frequency of 17.5 cm^{-1} for conditions both at vacuum and with 650 torr of N_2. The noise level was on the order of 100 to 120μV, which was totally unacceptable.

The noise level was greatly reduced by insulating the photoacoustic sphere. An enclosure was constructed from 3/4-inch particle board and was lined with 3-inch thick rock wool insulation on all six sides. The sphere was then mounted on isolation shock mounts and placed inside the particle board enclosure. This improved the system noise by bringing the noise level down to between 20 to 30μV. This enclosure also helped to minimize temperature changes and helped to keep the resonant frequency of the sphere from shifting around.

---

[4]B. L. Bean and S. Perkowitz, 1977, "Complete Frequency Covered for Submillimeter Laser Spectroscopy with Optically Pumped CH_3OH, CH_3OD, CD_3OD, and CH_2CF_2," <u>Optics Letters</u>, 1:202

With the noise level substantially reduced and better control of temperature fluctuations, it was now possible to attempt to make signal-to-noise measurements to determine system sensitivity.

While measurements were being conducted a number of important discoveries were made. First, the mechanical chopper was found to be too unstable for use on such a high-Q narrow-bandwidth system. Using the NMMW laser as the electromagnetic source for driving the spherical photoacoustic absorption chamber the resonant bandwidth was now less than 1 Hz. With a bandwidth this narrow it was impossible to tune the chopper to the resonant frequency. Because of instability the mechanical chopper would drift off resonance within a few seconds time.

To complicate matters even more during the short period of time when the chopper frequency was equal to the sphere's resonant frequency, the signal observed underwent phase changes which made normal lock-in amplifier signal processing techniques hard to use.

The lack of feedback circuitry necessary for controlling the CO_2 pump laser output contributed to the overall stability problem. Without this circuitry the CO_2 laser was constantly drifting in frequency which caused the NMMW laser output to drop off.

Table 1 shows the sensitivity results for various gaseous water vapor absorption pressure conditions and system noise levels. All measurements were made using the electret microphone designated as #2 on the machined aluminum sphere for consistency. Transducer electrets 1, 3, and 4 also produced comparable signal level magnitudes.

The same experimental procedures were used in evaluating the spun aluminum sphere enclosure, however, high noise levels with this sphere were not able to be overcome. Even with the spun aluminum sphere enclosed inside of the particle board and rock wool insulating enclosure, the noise level was in excess of $100 \mu V$ and no observable signal was seen even with 14 torr H_2O buffered to 650 torr with N_2 in the spherical enclosure. Therefore no measurements were obtainable from this system.

AFCRL absorption coefficients were calculated for the conditions found in table 1. These results along with their calculated absorption sensitivities [in units of $(km\text{-}watt)^{-1}$] are given in table 2.

ELECTRET DETECTOR INVESTIGATION/NEW SPECTROPHONE DESIGNS

Due to obvious adaptability problems, cylindrical gold or aluminum coated mylar diaphragms like those used in conventional single-pass photoacoustic absorption chambers[2] (spectrophones) could not be used in a spherical geometry chamber. The internally reflecting, spherically resonant enclosure required

---

[2]Charles Bruce, 1976, Development of Spectrophones for CW and Pulsed Radiation Sources, ECOM-5802, Atmospheric Sciences Laboratory, US Army Electronics Command, White Sands Missile Range, NM 88002

TABLE 1. SENSITIVITY RESULTS FOR VARIOUS WATER VAPOR PRESSURE

Laser Frequency (cm^{-1})	H_2O (Torr)	Total Pres $H_2O + N_2$ (Torr)	Resonance Frequency (Hz)	Noise Level (Avg) (μV)	Signal Level (Avg) (μV)	Signal to Noise Ratio
17.5	14	650	1926	20 μV	450.	22.5
17.5	7	300	1931	25 μV	200.	8.
17.5	2	300	1932	25 μV	45.0	1.8
17.5	0	650	1926	25 μV	—	—
17.5	0	0	1936	25 μV	—	—

TABLE 2. ABSORPTION SENSITIVITY

LASER FREQUENCY (CM^{-1})	H_2O CONCENTRATION (TORR)	TOTAL PRESSURE $H_2O + N_2$ (TORR)	AVERAGE SIGNAL-TO NOISE	AFCRL H_2O ABSORPTION COEFFICIENT (OCT. 1978 TAPE) $(KM)^{-1}$	ABSORPTION SENSITIVITY $(KM\text{-}WATT)^{-1}$
17.5	14	650	22.5	68.19	1.21×10^{-3}
17.5	7	300	8.0	17.37	8.68×10^{-4}
17.5	2	300	1.8	4.695	1.04×10^{-3}

NMM LASER FREQUENCY = $17.5\ cm^{-1}$

λ (μM) = 570.5

OUTPUT POWER = 0.2 mW

CO_2 LASER PUMP FREQUENCY = 9 p(16)

acoustic detectors with good sensitivity which were environmentally rugged and were compatible with this geometry. Miniature transducer electret microphones were chosen to be used as the acoustic detectors. Knowles type CA-1833 electrets were used on both spherical enclosures tested (figure 5). A graph showing detector sensitivity is shown in figure 6.

A parallel investigation was conducted to determine the applicability of single transducer electret type microphones as photoacoustic detectors in a conventional single-pass type spectrophones. Both type CA-1833 and the more sensitive type BT-1834 (also manufactured by Knowles electronics and just recently acquired) were used. Figure 7 shows the BT-1834 electret with its sensitivity curve shown in figure 8. Linearity and sensitivity tests have been run on a single-pass prototype spectrophone using both type detectors with very favorable results obtained in both cases. As a result tranducer electret microphones have been incorporated into three different spectrophone designs presently in use at ASL.

An HF/CO_2 pulsed source spectrophone is one such system now incorporating the transducer electret microphones. Figure 9 shows a schematic representation of this system. This system makes use of four BT-1834 type detectors placed 90 degrees apart midway along the length of the stainless steel cavity. The cavity has a 5/8-inch hole bored midway along its length. This cavity is then placed inside of an environmentally controllable vacuum tight chamber having brewster angle windows at each end. As the beam propagates down through the center of the cavity, some of the electromagnetic energy is absorbed by an absorbing media. Heating of the gas occurs with the resultant pressure change creating an acoustic wave. Due to the double open-ended organ pipe design, a pressure maximum occurs midway down the cavity. Because of the symetric placement of the four detectors in the cavity, the signals from each are in phase with one another. A summing amplifier was then used to sum the in phase signal magnitudes from each of the detectors with a resultant signal four times that of a single microphone signal. The response sensitivity figure from using this arrangement over a conventional mylar diaphragm microphone appears to be better by almost two orders of magnitude. Only continued testing will be able to verify this claim.

A NMMW laser intracavity spectrophone has also been designed incorporating the transducer electret microphones (figure 10). This spectrophone design is very similar to the HF/CO_2 pulsed source type previously mentioned. This system uses only one electret detector (type CA-1833) and the entire spectrophone is contained internal to the NMMW laser. Its placement is such that the optical pump beam from the CO_2 laser must pass down through the spectrophone cavity prior to entering through the rear optic of the near-millimeter laser cavity. By using the intracavity spectrophone, it is possible to optimize the output from the NMMW laser by tuning the CO_2 pump laser to obtain optimum absorption at the CO_2 frequency for the given NMMW laser pumping medium. The intracavity spectrophone has been incorporated into the NMMW laser and has proven to be very useful in optimizing output power of this system.

The third system developed, a differential type spectrophone, was constructed using the electret detectors (one CA-1833 electret in each side of the system). This system is represented schematically in figure 11. Tests have been conducted using this system, and, again, the preliminary findings have produced positive results.

CONCLUSIONS

Numerous problems were encountered with the spherical absorption chamber design. A combination of high-Q narrow-bandwidth characteristics, excessive noise sensitivities, mechanical chopping instabilities, resonant frequency temperature dependence, and continual signal phase changing made evaluation of the spherical spectrophone system extremely difficult. The use of a rock wool outer enclosure helped to eliminate some of the noise problems, but further improvements are required. Elimination of the rotating chopper arrangement by substitution of electronic modulation of the pump laser output would eliminate the chopper wheel resonant noise and the chopper instability problem. The high-Q temperature varying resonance characteristics mandate the use of frequency sweeping methods. This would require the use of computer controlled digital data processing approaches. In addition, amplifiers with phase locking features would be required. From tests performed so far, the absorption sensitivities obtained using the resonant sphere are not large enough to justify additional efforts at the present time.

The transducer electret microphones have been used as detectors in both resonant sphere and more conventional single-pass type resonant spectrophone geometries. Because of their sensitivity, environmental ruggedness, size, and compatibility with various spectrophone geometries, these microphones have proven to be very useful in various spectrophone applications. HF/CO_2 pulsed source, NMMW laser intracavity, and differential type spectrophones have been constructed incorporating the transducer electret microphones as detectors. Each of these three prototype spectrophone systems has produced favorable results in preliminary tests done so far at ASL.

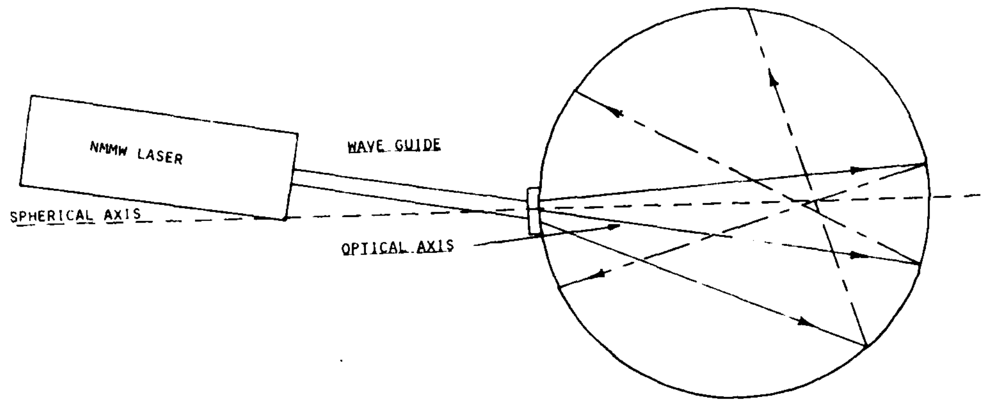


Figure 1. Proposed internally reflecting, spherically resonant enclosure.

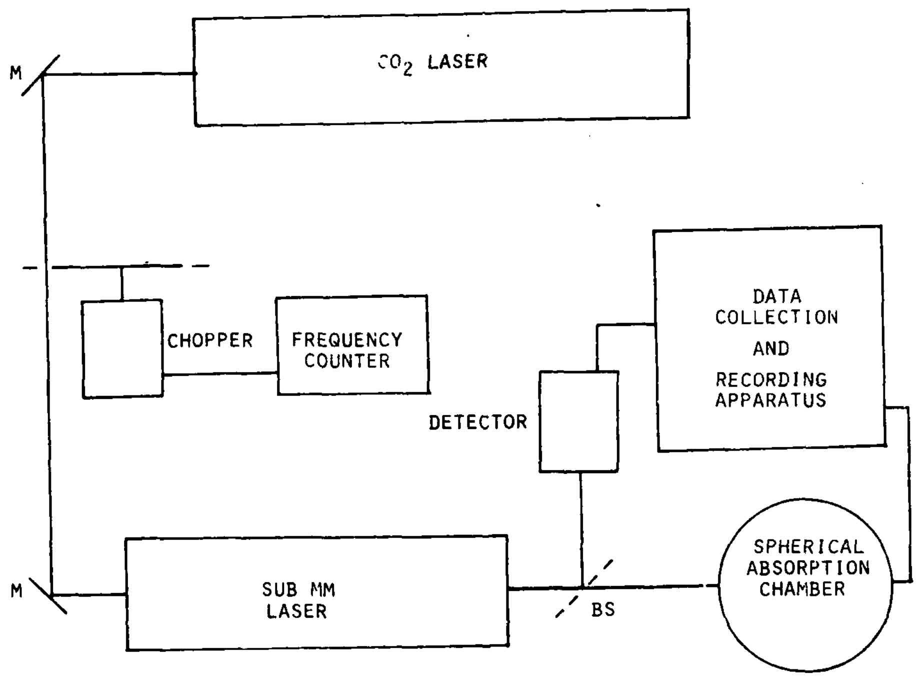


Figure 2. Experimental arrangement used to test internally reflecting, spherically resonant absorption.

Figure [illegible]. Spun aluminum enclosure.

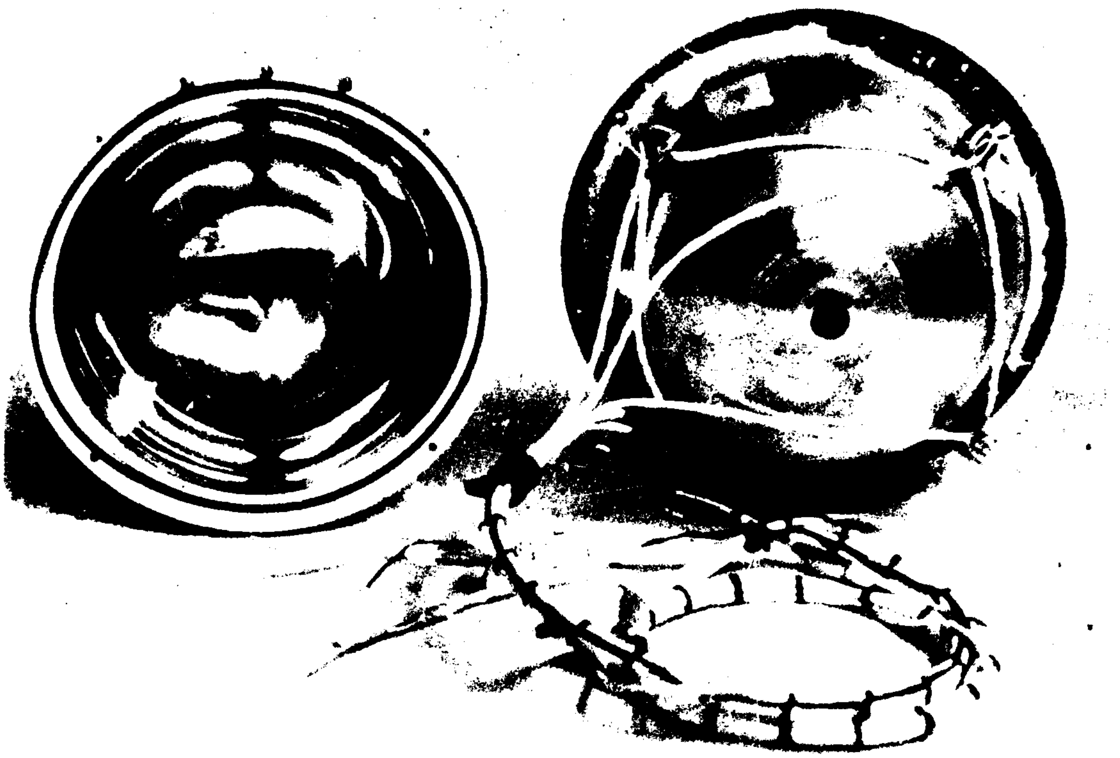


Figure 4. Machined aluminum.

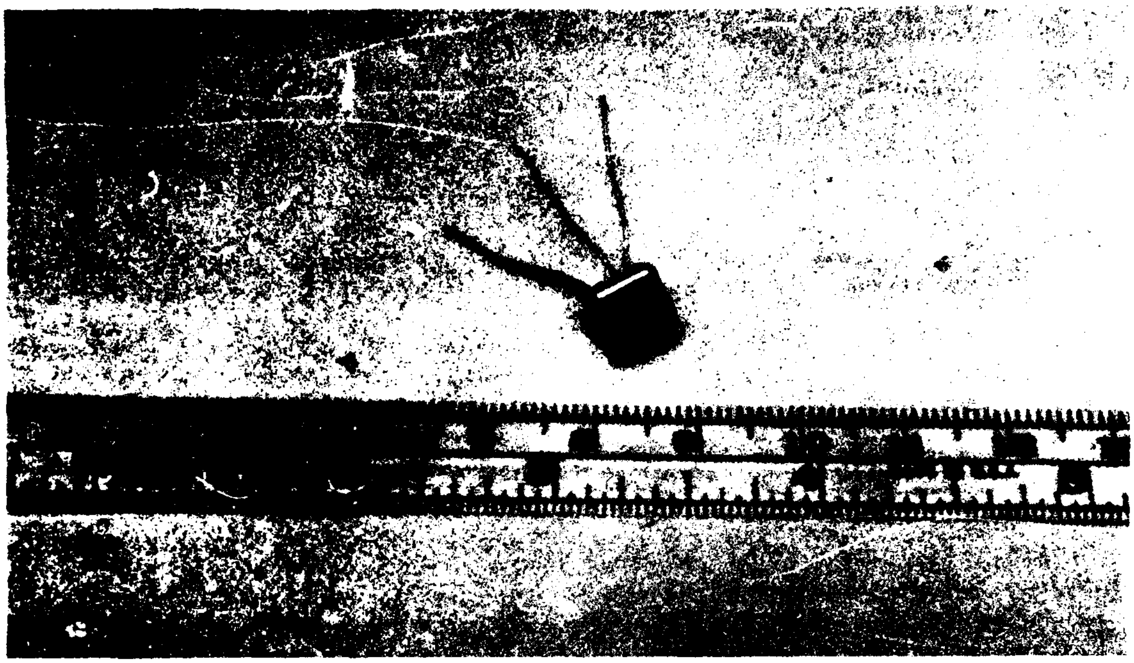
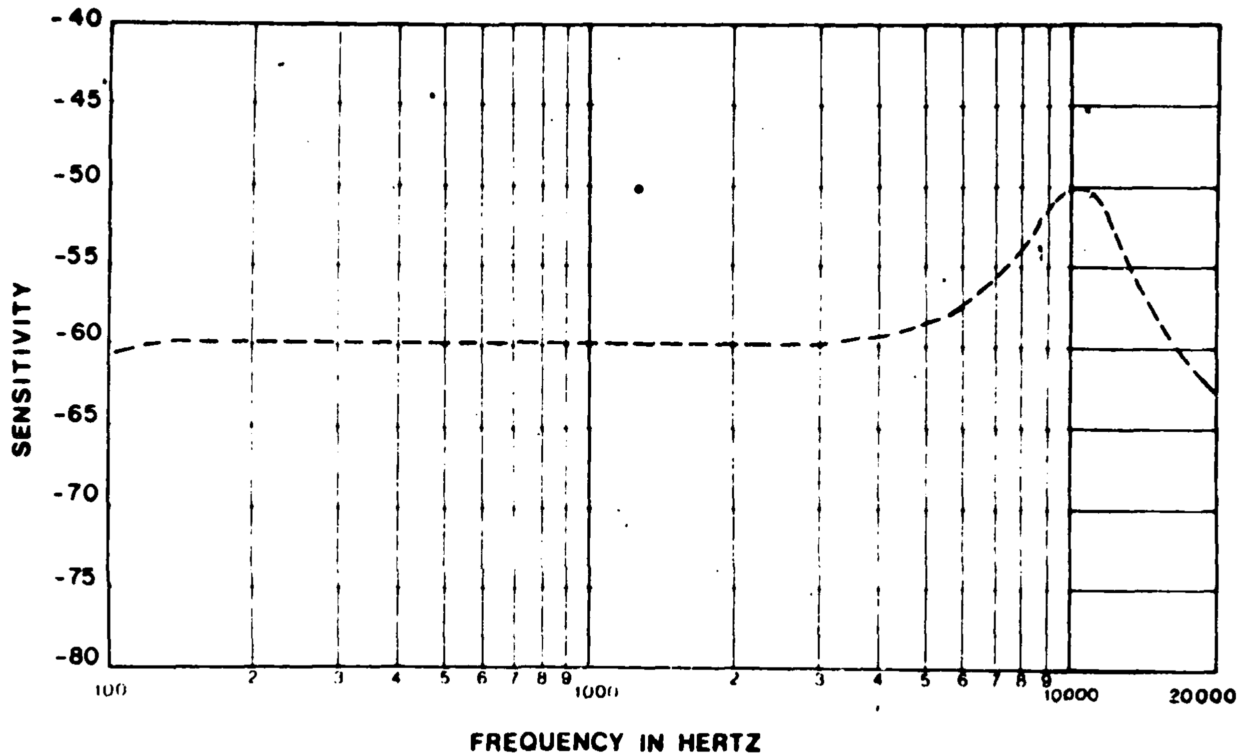


Figure 5. Electret detector type CA-1833.



OPEN CIRCUIT PRESSURE SENSITIVITY IN dB RELATIVE TO 1.0 VOLT/MICROBAR (0.1 N/m^2)

	SENSITIVITY (dB)		
FREQUENCY	MIN	NOM	MAX
100	---	-61	---
1000	-63	-60	-57
11000	---	-50.5	---

OUTPUT IMPENDANCE; 2500 OHMS MAX.

Figure 6. Electret detector type CA-1833 sensitivity.

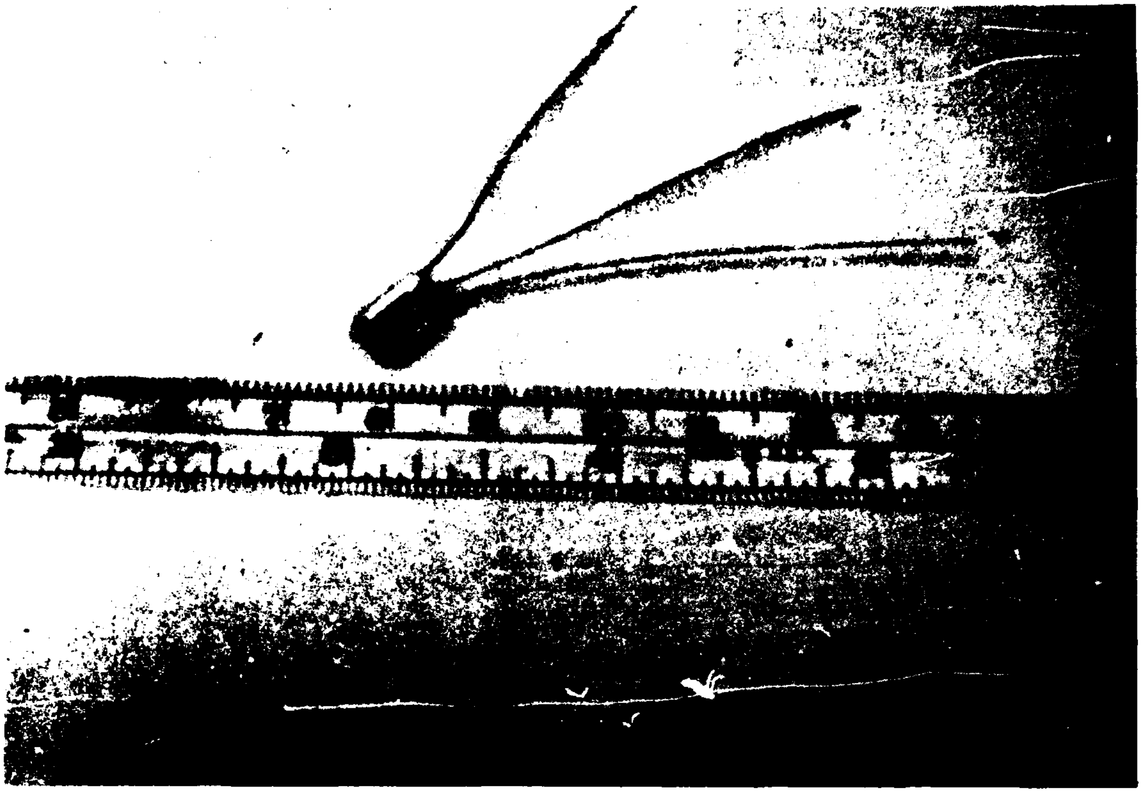
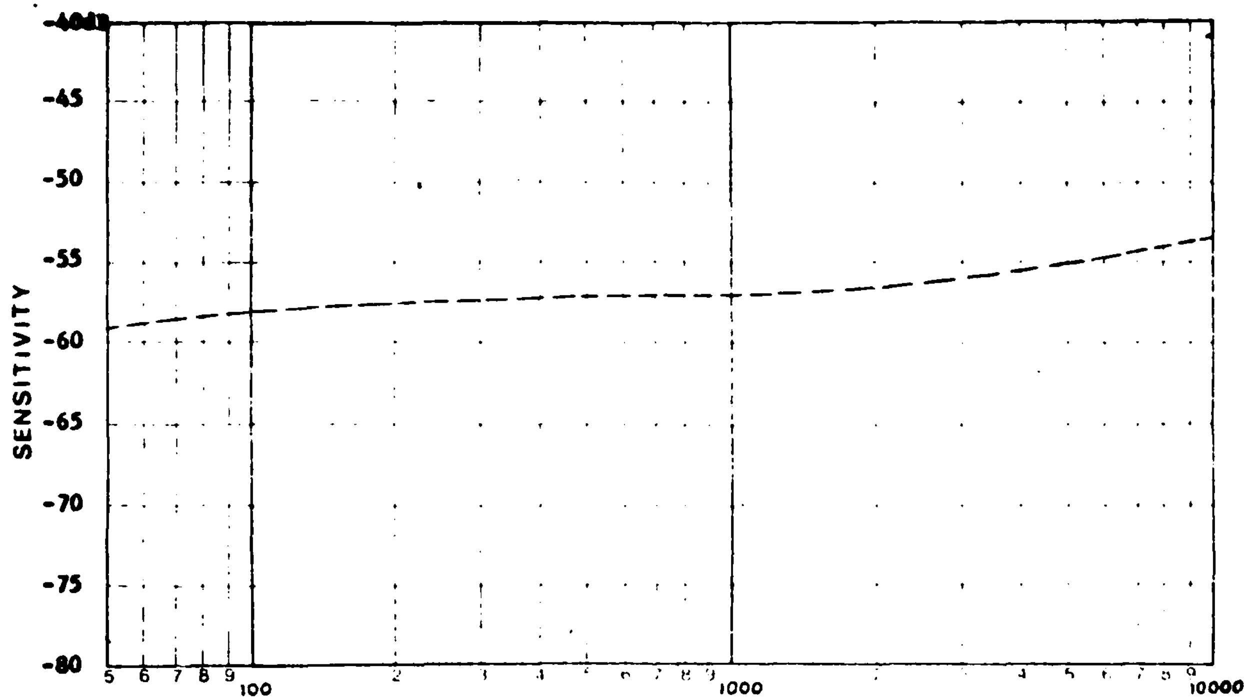


Figure 7. Electret detector type BT-1834.



OPEN CIRCUIT SENSITIVITY IN dB RELATIVE TO 1.0 VOLT/MICROBAR (0.1 N/m^2)

FREQUENCY	SENSITIVITY (dB) MIN.	NOM.	MAX.
100	----	-58.0	----
1000	-60.0	-57.0	-54.0
10000	----	-53.5	----

OUTPUT IMPENDANCE: 2000 TO 6000 OHMS
(3500 OHMS NOMINAL).

Figure 8. Electret detector type BT-1834 sensitivity.

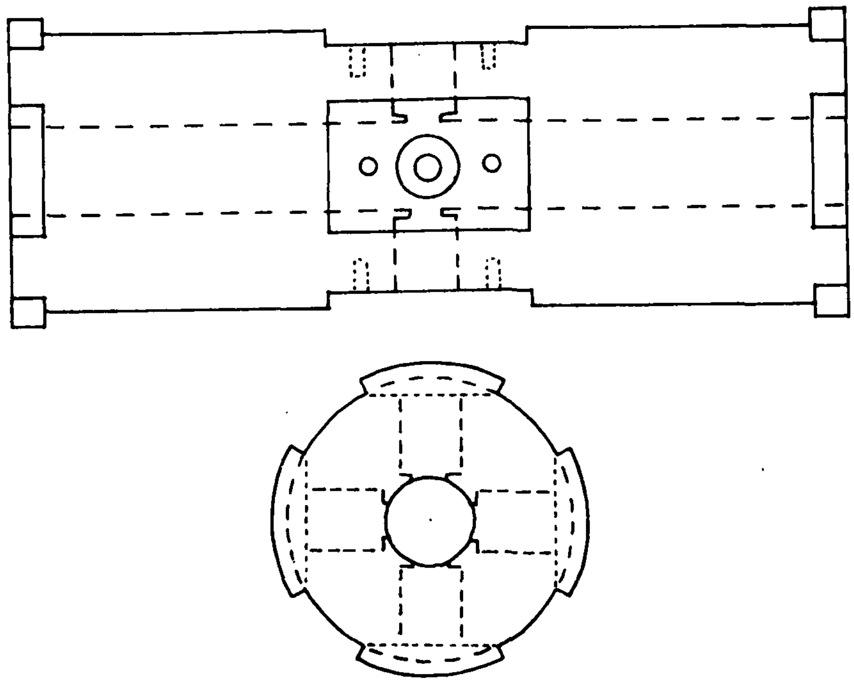


Figure 9. HF/CO_2 pulsed spectrophone using four electret detectors.

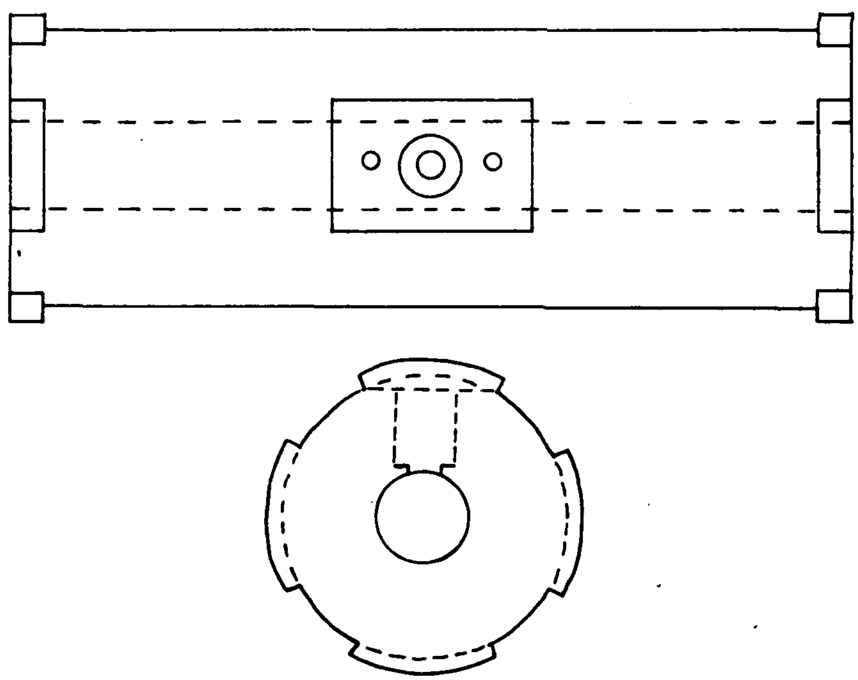


Figure 10 Intracavity near-millimeter wave laser spectrophone using one electret detector.

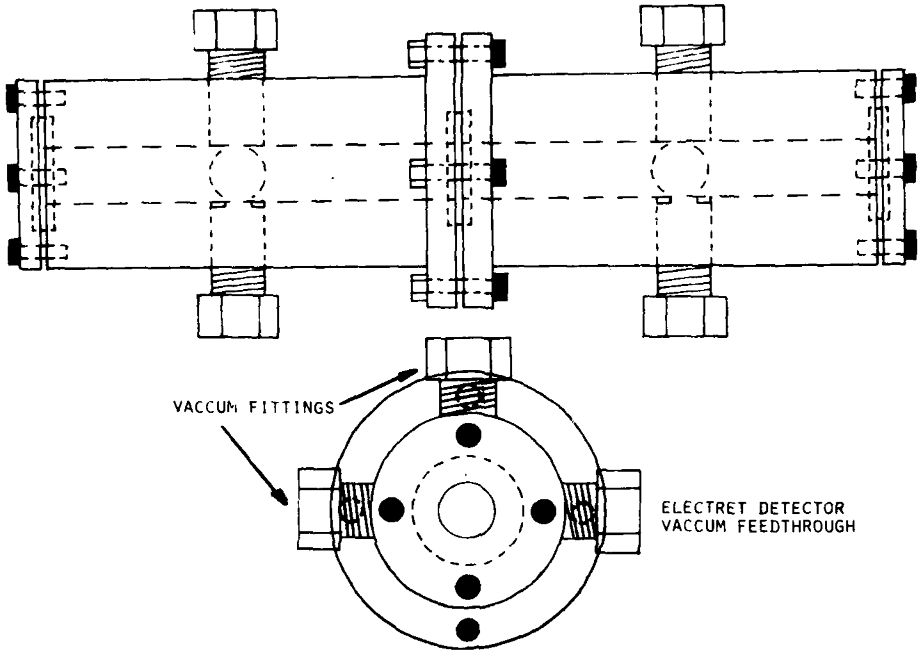


Figure 11. Differential type spectrophone using two delectret detectors.

DISTRIBUTION LIST

Commander
US Army Aviation Center
ATTN: ATZQ-D-MA
Fort Rucker, AL 36362

Chief, Atmospheric Sciences Div
Code ES-81
NASA
Marshall Space Flight Center, AL 35812

Commander
US Army Missile Command
ATTN: DRDMI-RRA/Dr.O. M. Essenwanger
Redstone Arsenal, AL 35809

Commander
US Army Missile Command
ATTN: DRSMI-OG (B. W. Fowler)
Redstone Arsenal, AL 35809

Commander
US Army Missile R&D Command
ATTN: DRDMI-TEM (R. Haraway)
Redstone Arsenal, AL 35809

Redstone Scientific Information Center
ATTN: DRSMI-RPRD (Documents)
US Army Missile Command
Redstone Arsenal, AL 35809

Commander
HQ, Fort Huachuca
ATTN: Tech Ref Div
Fort Huachuca, AZ 85613

Commander
US Army Intelligence
Center & School
ATTN: ATSI-CD-MD
Fort Huachuca, AZ 85613

Commander
US Army Yuma Proving Ground
ATTN: Technical Library
Bldg 2105
Yuma, AZ 85364

Dr. Frank D. Eaton
Geophysical Institute
University of Alaska
Fairbanks, AK 99701

Naval Weapons Center
Code 3918
ATTN: Dr. A. Shlanta
China Lake, CA 93555

Commanding Officer
Naval Envir Prediction Rsch Facility
ATTN; Library
Monterey, CA 93940

Sylvania Elec Sys Western Div
ATTN: Technical Reports Lib
PO Box 205
Mountain View, CA 94040

Geophysics Officer
PMTC Code 3250
Pacific Missile Test Center
Point Mugu, CA 93042

Commander
Naval Ocean Systems Center
(Code 4473)
ATTN: Technical Library
San Diego, CA 92152

Meteorologist in Charge
Kwajalein Missile Range
PO Box 67
APO San Francisco, CA 96555

Director
NOAA/ERL/APCL R31
RB3-Room 567
Boulder, CO 80302

Dr.B. A. Silverman D-1200
Office of Atmos Resources Management
Water and Power Resources Service
PO Box 25007Denver Federal Center, Bldg. 67
Denver, CO 80225

Hugh W. Albers (Executive Secretary)
CAO Subcommittee on Atmos Rsch
National Science Foundation Room 510
Washington, DC 2055

Dr. Eugene W. Bierly
Director, Division of Atmos Sciences
National Scinece Foundation
1800 G Street, N.W.
Washington, DC 20550

Commanding Officer
Naval Research Laboratory
Code 2627
Washington, DC 20375

Defense Communications Agency
Technical Library Center
Code 222
Washington, DC 20305

Director
Naval Research Laboratory
Code 5530
Washington, DC 20375

Dr. J. M. MacCallum
Naval Research Laboratory
Code 1409
Washington, DC 20375

HQDA (DAEN-RDM/Dr. de Percin)
Washington, DC 20314

The Library of Congress
ATTN: Exchange & Gift Div
Washington, DC 20540
2

Mil Asst for Atmos Sci Ofc of
the Undersecretary of Defense
for Rsch & Engr/E&LS - RM 3D129
The Pentagon
Washington, DC 20301

AFATL/DLODL
Technical Library
Eglin AFB, FL 32542

Naval Training Equipment Center
ATTN: Technical Information Center
Orlando, FL 32813

Technical Library
Chemical Systems Laboratory
Aberdeen Proving Ground, MD 21010

US Army Materiel Systems
Analysis Activity
ATTN: DRXSY-MP
APG, MD 21005

Commander
ERADCOM
ATTN: DRDEL-PA/ILS/-ED
2800 Powder Mill Road
Adelphi, MD 20783

Commander
ERADCOM
ATTN: DRDEL-ST-T (Dr. B. Zarwyn)
2800 Powder Mill Road
Adelphi, MD 20783
02

Commander
Harry Diamond Laboratories
ATTN: DELHD-CO
2800 Powder Mill Road
Adelphi, MD 20783

Chief
Intel Mat Dev & Spt Ofc
ATTN: DELEW-WL-I
Bldg 4554
Fort George G. Mead, MD 20755

Acquisitions Section, IRDB-D823
Library & Info Svc Div, NOAA
6009 Executive Blvd.
Rockville, MD 20752

Naval Surface Weapons Center
White Oak Library
Silver Spring, MD 20910

Air Force Geophysics Laboratory
ATTN: LCC (A. S. Carten, Jr.)
Hanscom AFB, MA 01731

Air Force Geophysics Laboratory
ATTN: LYD
Hanscom AFB, MA 01731

Meteorology Division
AFGL/LY
Hanscom AFB, MA 01731

The Environmental Research
Institute of MI
ATTN: IRIA Library
PO Box 8618
Ann Arbor, MI 48107

Mr. William A. Main
USDA Forest Service
1407 S. Harrison Road
East Lansing, MI 48823

Dr. A. D. Belmont
Research Division
PO Box 1249
Control Data Corp
Minneapolis, MN 55440

Commander
Naval Oceanography Command
Bay St. Louis, MS 39529

Commanding Officer
US Army Armament R&D Command
ATTN; DRDAR-TSS Bldg 59
Dover, NJ 07801

Commander
ERADCOM Scientific Advisor
ATTN: DRDEL-SA
Fort Monmouth, NJ 07703

Commander
ERADCOM Tech Support Activity
ATTN: DELSD-L
Fort Monmouth, NJ 07703

Commander
HQ, US Army Avionics R&D Actv
ATTN: DAVAA-O
Fort Monmouth, NJ 07703

Commander
USA Elect Warfare Lab
ATTN: DELEW-DA (File Cy)
Fort Monmouth, NJ 07703

Commander
US Army Electronics R&D Command
ATTN: DELCS-S
Fort Monmouth, NJ 07703

Commander
US Army Satellite Comm Agency
ATTN: DRCPM-SC-3
Fort Monmouth, NJ 07703

Commander/Director
US Army Combat Survl & Target
Acquisition Laboratory
ATTN: DELCS-D
Fort Monmouth, NJ 07703

Director
Night Vision & Electro-Optics Laboratory
ATTN: DELNV-L (Dr. R. Buser)
Fort Belvoir, VA 22060

Project Manager, FIREFINDER
ATTN: DRCPM-FF
Fort Monmouth, NJ 07703

PM, Firefinder/REMBASS
ATTN: DRCPM-FFR-TM
Fort Monmouth, NJ 07703

6585 TG/WE
Holloman AFB, NM 88330

AFWL/Technical Library (SUL)
Kirtland AFB, NM 87117

AFWL/WE
Kirtland, AFB, NM 87117

TRASANA
ATTN: ATAA-SL (D. Anguiano)
WSMR, NM 88002

Commander
US Army White Sands Missile Range
ATTN: STEWS-PT-AL
White Sands Missile Range, NM 88002

Rome Air Development Center
ATTN: Documents Library
TSLD (Bette Smith)
Griffiss AFB, NY 13441

Environmental Protection Agency
Meteorology Laboratory, MD 80
Rsch Triangle Park, NC 27711

US Army Research Office
ATTN: DRXRO-PP
PO Box 12211
Rsch Triangle Park, NC 27709

Commandant
US Army Field Artillery School
ATTN: ATSF-CD-MS (Mr. Farmer)
Fort Sill, OK 73503

Commandant
US Army Field Artillery School
ATTN: ATSF-CF-R
Fort Sill, OK 73503

Commandant
US Army Field Artillery School
ATTN: Morris Swett Library
Fort Sill, OK 73503

Commander
US Army Dugway Proving Ground
ATTN: STEDP-MT-DA-M
(Mr. Paul Carlson)
Dugway, UT 84022

Commander
US Army Dugway Proving Ground
ATTN: MT-DA-L
Dugway, UT 84022

US Army Dugway Proving Ground
ATTN: STEDP-MT-DA-T
(Dr. W. A. Peterson)
Dugway, UT 84022

Inge Dirmhirn, Professor
Utah State University, UMC 48
Logan, UT 84322

Defense Technical Information Center
ATTN: DTIC-DDA-2
Cameron Station, Bldg. 5
Alexandria, VA 22314
12

Commanding Officer
US Army Foreign Sci & Tech Cen
ATTN: DRXST-IS1
220 7th Street, NE
Charlottesville, VA 22901

Naval Surface Weapons Center
Code G65
Dahlgren, VA 22448

Commander
US Army Night Vision
& Electro-Optics Lab
ATTN: DELNV-D
Fort Belvoir, VA 22060

Commander
USATRADOC
ATTN: ATCD-FA
Fort Monroe, VA 23651

Commander
USATRADOC
ATTN: ATCD-IR
Fort Monroe, VA 23651

Dept of the Air Force
5WW/DN
Langley AFB, VA 23665

US Army Nuclear & Cml Agency
ATTN: MONA-WE
Springfield, VA 22150

Director
US Army Signals Warfare Lab
ATTN: DELSW-OS (Dr. Burkhardt)
Vint Hill Farms Station
Warrenton, VA 22186

Commander
US Army Cold Regions Test Cen
ATTN: STECR-OP-PM
APO Seattle, WA 98733

ATMOSPHERIC SCIENCES RESEARCH REPORTS

1. Lindberg, J. D., "An Improvement to a Method for Measuring the Absorption Coefficient of Atmospheric Dust and other Strongly Absorbing Powders," ECOM-5565, July 1975.

2. Avara, Elton P., "Mesoscale Wind Shears Derived from Thermal Winds," ECOM-5566, July 1975.

3. Gomez, Richard B., and Joseph H. Pierluissi, "Incomplete Gamma Function Approximation for King's Strong-Line Transmittance Model," ECOM-5567, July 1975.

4. Blanco, A. J., and B. F. Engebos, "Ballistic Wind Weighting Functions for Tank Projectiles," ECOM-5568, August 1975.

5. Taylor, Fredrick J., Jack Smith, and Thomas H. Pries, "Crosswind Measurements through Pattern Recognition Techniques," ECOM-5569, July 1975.

6. Walters, D. L., "Crosswind Weighting Functions for Direct-Fire Projectiles," ECOM-5570, August 1975.

7. Duncan, Louis D., "An Improved Algorithm for the Iterated Minimal Information Solution for Remote Sounding of Temperature," ECOM-5571, August 1975.

8. Robbiani, Raymond L., "Tactical Field Demonstration of Mobile Weather Radar Set AN/TPS-41 at Fort Rucker, Alabama," ECOM-5572, August 1975.

9. Miers, B., G. Blackman, D. Langer, and N. Lorimier, "Analysis of SMS/GOES Film Data," ECOM-5573, September 1975.

10. Manquero, Carlos, Louis Duncan, and Rufus Bruce, "An Indication from Satellite Measurements of Atmospheric CO_2 Variability," ECOM-5574, September 1975.

11. Petracca, Carmine, and James D. Lindberg, "Installation and Operation of an Atmospheric Particulate Collector," ECOM-5575, September 1975.

12. Avara, Elton P., and George Alexander, "Empirical Investigation of Three Iterative Methods for Inverting the Radiative Transfer Equation," ECOM-5576, October 1975.

13. Alexander, George D., "A Digital Data Acquisition Interface for the SMS Direct Readout Ground Station - Concept and Preliminary Design," ECOM-5577, October 1975.

14. Cantor, Israel, "Enhancement of Point Source Thermal Radiation Under Clouds in a Nonattenuating Medium," ECOM-5578, October 1975.

15. Norton, Colburn, and Glenn Hoidale, "The Diurnal Variation of Mixing Height by Month over White Sands Missile Range, NM," ECOM-5579, November 1975.

16. Avara, Elton P., "On the Spectrum Analysis of Binary Data," ECOM-5580, November 1975.

17. Taylor, Fredrick J., Thomas H. Pries, and Chao-Huan Huang, "Optimal Wind Velocity Estimation," ECOM-5581, December 1975.

18. Avara, Elton P., "Some Effects of Autocorrelated and Cross-Correlated Noise on the Analysis of Variance," ECOM-5582, December 1975.

19. Gillespie, Patti S., R. L. Armstrong, and Kenneth O. White, "The Spectral Characteristics and Atmospheric CO_2 Absorption of the Ho^{+3}:YLF Laser at 2.05μm," ECOM-5583, December 1975.

20. Novlan, David J., "An Empirical Method of Forecasting Thunderstorms for the White Sands Missile Range," ECOM-5584, February 1976.

21. Avara, Elton P., "Randomization Effects in Hypothesis Testing with Autocorrelated Noise," ECOM-5585, February 1976.

22. Watkins, Wendell R., "Improvements in Long Path Absorption Cell Measurement," ECOM-5586, March 1976.

23. Thomas, Joe, George D. Alexander, and Marvin Dubbin, "SATTEL - An Army Dedicated Meteorological Telemetry System," ECOM-5587, March 1976.

24. Kennedy, Bruce W., and Delbert Bynum, "Army User Test Program for the RDT&E-XM-75 Meteorological Rocket," ECOM-5588, April 1976.

25. Barnett, Kenneth M., "A Description of the Artillery Meteorological Comparisons at White Sands Missile Range, October 1974 - December 1974 ('PASS' - Prototype Artillery [Meteorological] Subsystem)," ECOM-5589, April 1976.

26. Miller, Walter B., "Preliminary Analysis of Fall-of-Shot From Project 'PASS'," ECOM-5590, April 1976.

27. Avara, Elton P., "Error Analysis of Minimum Information and Smith's Direct Methods for Inverting the Radiative Transfer Equation," ECOM-5591, April 1976.

28. Yee, Young P., James D. Horn, and George Alexander, "Synoptic Thermal Wind Calculations from Radiosonde Observations Over the Southwestern United States," ECOM-5592, May 1976.

29. Duncan, Louis D., and Mary Ann Seagraves, "Applications of Empirical Corrections to NOAA-4 VTPR Observations," ECOM-5593, May 1976.

30. Miers, Bruce T., and Steve Weaver, "Applications of Meteorological Satellite Data to Weather Sensitive Army Operations," ECOM-5594, May 1976.

31. Sharenow, Moses, "Redesign and Improvement of Balloon ML-566," ECOM-5595, June 1976.

32. Hansen, Frank V., "The Depth of the Surface Boundary Layer," ECOM-5596, June 1976.

33. Pinnick, R. G., and E. B. Stenmark, "Response Calculations for a Commerical Light-Scattering Aerosol Counter," ECOM-5597, July 1976.

34. Mason, J., and G. B. Hoidale, "Visibility as an Estimator of Infrared Transmittance," ECOM-5598, July 1976.

35. Bruce, Rufus E., Louis D. Duncan, and Joseph H. Pierluissi, "Experimental Study of the Relationship Between Radiosonde Temperatures and Radiometric-Area Temperatures," ECOM-5599, August 1976.

36. Duncan, Louis D., "Stratospheric Wind Shear Computed from Satellite Thermal Sounder Measurements," ECOM-5800, September 1976.

37. Taylor, F., P. Mohan, P. Joseph, and T. Pries, "An All Digital Automated Wind Measurement System," ECOM-5801, September 1976.

38. Bruce, Charles, "Development of Spectrophones for CW and Pulsed Radiation Sources," ECOM-5802, September 1976.

39. Duncan, Louis D., and Mary Ann Seagraves, "Another Method for Estimating Clear Column Radiances," ECOM-5803, October 1976.

40. Blanco, Abel J., and Larry E. Taylor, "Artillery Meteorological Analysis of Project Pass," ECOM-5804, October 1976.

41. Miller, Walter, and Bernard Engebos, "A Mathematical Structure for Refinement of Sound Ranging Estimates," ECOM-5805, November 1976.

42. Gillespie, James B., and James D. Lindberg, "A Method to Obtain Diffuse Reflectance Measurements from 1.0 and 3.0μm Using a Cary 17I Spectrophotometer," ECOM-5806, November 1976.

43. Rubio, Roberto, and Robert O. Olsen, "A Study of the Effects of Temperature Variations on Radio Wave Absorption," ECOM-5807, November 1976.

44. Ballard, Harold N., "Temperature Measurements in the Stratosphere from Balloon-Borne Instrument Platforms, 1968-1975," ECOM-5808, December 1976.

45. Monahan, H. H., "An Approach to the Short-Range Prediction of Early Morning Radiation Fog," ECOM-5809, January 1977.

46. Engebos, Bernard Francis, "Introduction to Multiple State Multiple Action Decision Theory and Its Relation to Mixing Structures," ECOM-5810, January 1977.

47. Low, Richard D. H., "Effects of Cloud Particles on Remote Sensing from Space in the 10-Micrometer Infrared Region," ECOM-5811, January 1977.

48. Bonner, Robert S., and R. Newton, "Application of the AN/GVS-5 Laser Rangefinder to Cloud Base Height Measurements," ECOM-5812, February 1977.

49. Rubio, Roberto, "Lidar Detection of Subvisible Reentry Vehicle Erosive Atmospheric Material," ECOM-5813, Marcy 1977.

50. Low, Richard D. H., and J. D. Horn, "Mesoscale Determination of Cloud-Top Height: Problems and Solutions," ECOM-5814, March 1977.

51. Duncan, Louis D., and Mary Ann Seagraves, "Evaluation of the NOAA-4 VTPR Thermal Winds for Nuclear Fallout Predictions," ECOM-5815, March 1977.

52. Randhawa, Jagir S., M. Izquierdo, Carlos McDonald, and Zvi Salpeter, "Stratospheric Ozone Density as Measured by a Chemiluminescent Sensor During the Stratcom VI-A Flight," ECOM-5816, April 1977.

53. Rubio, Roberto, and Mike Izquierdo, "Measurements of Net Atmospheric Irradiance in the 0.7- to 2.8-Micrometer Infrared Region," ECOM-5817, May 1977.

54. Ballard, Harold N., Jose M. Serna, and Frank P. Hudson, Consultant for Chemical Kinetics, "Calculation of Selected Atmospheric Composition Parameters for the Mid-Latitude, September Stratosphere," ECOM-5818, May 1977.

55. Mitchell, J. D., R. S. Sagar, and R. O. Olsen, "Positive Ions in the Middle Atmosphere During Sunrise Conditions," ECOM-5819, May 1977.

56. White, Kenneth O., Wendell R. Watkins, Stuart A. Schleusener, and Ronald L. Johnson, "Solid-State Laser Wavelength Identification Using a Reference Absorber," ECOM-5820, June 1977.

57. Watkins, Wendell R., and Richard G. Dixon, "Automation of Long-Path Absorption Cell Measurements," ECOM-5821, June 1977.

58. Taylor, S. E., J. M. Davis, and J. B. Mason, "Analysis of Observed Soil Skin Moisture Effects on Reflectance," ECOM-5822, June 1977.

59. Duncan, Louis D., and Mary Ann Seagraves, "Fallout Predictions Computed from Satellite Derived Winds," ECOM-5823, June 1977.

60. Snider, D. E., D. G. Murcray, F. H. Murcray, and W. J. Williams, "Investigation of High-Altitude Enhanced Infrared Backround Emissions," (U), SECRET, ECOM-5824, June 1977.

61. Dubbin, Marvin H., and Dennis Hall, "Synchronous Meteorological Satellite Direct Readout Ground System Digital Video Electronics," ECOM-5825, June 1977.

62. Miller, W., and B. Engebos, "A Preliminary Analysis of Two Sound Ranging Algorithms," ECOM-5826, July 1977.

63. Kennedy, Bruce W., and James K. Luers, "Ballistic Sphere Techniques for Measuring Atmospheric Parameters," ECOM-5827, July 1977.

64. Duncan, Louis D., "Zenith Angle Variation of Satellite Thermal Sounder Measurements," ECOM-5828, August 1977.

65. Hansen, Frank V., "The Critical Richardson Number," ECOM-5829, September 1977.

66. Ballard, Harold N., and Frank P. Hudson (Compilers), "Stratospheric Composition Balloon-Borne Experiment," ECOM-5830, October 1977.

67. Barr, William C., and Arnold C. Peterson, "Wind Measuring Accuracy Test of Meteorological Systems," ECOM-5831, November 1977.

68. Ethridge, G. A., and F. V. Hansen, "Atmospheric Diffusion: Similarity Theory and Empirical Derivations for Use in Boundary Layer Diffusion Problems," ECOM-5832, November 1977.

69. Low, Richard D. H., "The Internal Cloud Radiation Field and a Technique for Determining Cloud Blackness," ECOM-5833, December 1977.

70. Watkins, Wendell R., Kenneth O. White, Charles W. Bruce, Donald L. Walters, and James D. Lindberg, "Measurements Required for Prediction of High Energy Laser Transmission," ECOM-5834, December 1977.

71. Rubio, Robert, "Investigation of Abrupt Decreases in Atmospherically Backscattered Laser Energy," ECOM-5835, December 1977.

72. Monahan, H. H., and R. M. Cionco, "An Interpretative Review of Existing Capabilities for Measuring and Forecasting Selected Weather Variables (Emphasizing Remote Means)," ASL-TR-0001, January 1978.

73. Heaps, Melvin G., "The 1979 Solar Eclipse and Validation of D-Region Models," ASL-TR-0002, March 1978.

74. Jennings, S. G., and J. B. Gillespie, "M.I.E. Theory Sensitivity Studies - The Effects of Aerosol Complex Refractive Index and Size Distribution Variations on Extinction and Absorption Coefficients, Part II: Analysis of the Computational Results," ASL-TR-0003, March 1978.

75. White, Kenneth O., et al, "Water Vapor Continuum Absorption in the 3.5μm to 4.0μm Region," ASL-TR-0004, March 1978.

76. Olsen, Robert O., and Bruce W. Kennedy, "ABRES Pretest Atmospheric Measurements," ASL-TR-0005, April 1978.

77. Ballard, Harold N., Jose M. Serna, and Frank P. Hudson, "Calculation of Atmospheric Composition in the High Latitude September Stratosphere," ASL-TR-0006, May 1978.

78. Watkins, Wendell R., et al, "Water Vapor Absorption Coefficients at HF Laser Wavelengths," ASL-TR-0007, May 1978.

79. Hansen, Frank V., "The Growth and Prediction of Nocturnal Inversions," ASL-TR-0008, May 1978.

80. Samuel, Christine, Charles Bruce, and Ralph Brewer, "Spectrophone Analysis of Gas Samples Obtained at Field Site," ASL-TR-0009, June 1978.

81. Pinnick, R. G., et al., "Vertical Structure in Atmospheric Fog and Haze and its Effects on IR Extinction," ASL-TR-0010, July 1978.

82. Low, Richard D. H., Louis D. Duncan, and Richard B. Gomez, "The Microphysical Basis of Fog Optical Characterization," ASL-TR-0011, August 1978.

83. Heaps, Melvin G., "The Effect of a Solar Proton Event on the Minor Neutral Constituents of the Summer Polar Mesosphere," ASL-TR-0012, August 1978.

84. Mason, James B., "Light Attenuation in Falling Snow," ASL-TR-0013, August 1978.

85. Blanco, Abel J., "Long-Range Artillery Sound Ranging: 'PASS' Meteorological Application," ASL-TR-0014, September 1978.

86. Heaps, M. G., and F. E. Niles, "Modeling of Ion Chemistry of the D-Region: A Case Study Based Upon the 1966 Total Solar Eclipse," ASL-TR-0015, September 1978.

87. Jennings, S. G., and R. G. Pinnick, "Effects of Particulate Complex Refractive Index and Particle Size Distribution Variations on Atmospheric Extinction and Absorption for Visible Through Middle-Infrared Wavelengths," ASL-TR-0016, September 1978.

88. Watkins, Wendell R., Kenneth O. White, Lanny R. Bower, and Brian Z. Sojka, "Pressure Dependence of the Water Vapor Continuum Absorption in the 3.5- to 4.0-Micrometer Region," ASL-TR-0017, September 1978.

89. Miller, W. B., and B. F. Engebos, "Behavior of Four Sound Ranging Techniques in an Idealized Physical Environment," ASL-TR-0018, September 1978.

90. Gomez, Richard G., "Effectiveness Studies of the CBU-88/B Bomb, Cluster, Smoke Weapon," (U), CONFIDENTIAL ASL-TR-0019, September 1978.

91. Miller, August, Richard C. Shirkey, and Mary Ann Seagraves, "Calculation of Thermal Emission from Aerosols Using the Doubling Technique," ASL-TR-0020, November 1978.

92. Lindberg, James D., et al, "Measured Effects of Battlefield Dust and Smoke on Visible, Infrared, and Millimeter Wavelengths Propagation: A Preliminary Report on Dusty Infrared Test-I (DIRT-I)," ASL-TR-0021, January 1979.

93. Kennedy, Bruce W., Arthur Kinghorn, and B. R. Hixon, "Engineering Flight Tests of Range Meteorological Sounding System Radiosonde," ASL-TR-0022, February 1979.

94. Rubio, Roberto, and Don Hoock, "Microwave Effective Earth Radius Factor Variability at Wiesbaden and Balboa," ASL-TR-0023, February 1979.

95. Low, Richard D. H., "A Theoretical Investigation of Cloud/Fog Optical Properties and Their Spectral Correlations, "ASL-TR-0024, February 1979.

96. Pinnick, R. G., and H. J. Auvermann, "Response Characteristics of Knollenberg Light-Scattering Aerosol Counters," ASL-TR-0025, February 1979.

97. Heaps, Melvin G., Robert O. Olsen, and Warren W. Berning, "Solar Eclipse 1979, Atmospheric Sciences Laboratory Program Overview," ASL-TR-0026, February 1979.

98. Blanco, Abel J., "Long-Range Artillery Sound Ranging: 'PASS' GR-8 Sound Ranging Data," ASL-TR-0027, March 1979.

99. Kennedy, Bruce W., and Jose M. Serna, "Meteorological Rocket Network System Reliability," ASL-TR-0028, March 1979.

100. Swingle, Donald M., "Effects of Arrival Time Errors in Weighted Range Equation Solutions for Linear Base Sound Ranging," ASL-TR-0029, April 1979.

101. Umstead, Robert K., Ricardo Pena, and Frank V. Hansen, "KWIK: An Algorithm for Calculating Munition Expenditures for Smoke Screening/Obscuration in Tactical Situations," ASL-TR-0030, April 1979.

102. D'Arcy, Edward M., "Accuracy Validation of the Modified Nike Hercules Radar," ASL-TR-0031, May 1979.

103. Rodriguez, Ruben, "Evaluation of the Passive Remote Crosswind Sensor," ASL-TR-0032, May 1979.

104. Barber, T. L., and R. Rodriguez, "Transit Time Lidar Measurement of Near-Surface Winds in the Atmosphere," ASL-TR-0033, May 1979.

105. Low, Richard D. H., Louis D. Duncan, and Y. Y. Roger R. Hsiao, "Microphysical and Optical Properties of California Coastal Fogs at Fort Ord," ASL-TR-0034, June 1979.

106. Rodriguez, Ruben, and William J. Vechione, "Evaluation of the Saturation Resistant Crosswind Sensor," ASL-TR-0035, July 1979.

107. Ohmstede, William D., "The Dynamics of Material Layers," ASL-TR-0036, July 1979.

108. Pinnick, R. G., S. G. Jennings, Petr Chylek, and H. J. Auvermann, "Relationships between IR Extinction Absorption, and Liquid Water Content of Fogs," ASL-TR-0037, August 1979.

109. Rodriguez, Ruben, and William J. Vechione, "Performance Evaluation of the Optical Crosswind Profiler," ASL-TR-0038, August 1979.

110. Miers, Bruce T., "Precipitation Estimation Using Satellite Data," ASL-TR-0039, September 1979.

111. Dickson, David H., and Charles M. Sonnenschein, "Helicopter Remote Wind Sensor System Description," ASL-TR-0040, September 1979.

112. Heaps, Melvin G., and Joseph M. Heimerl, "Validation of the Dairchem Code, I: Quiet Midlatitude Conditions," ASL-TR-0041, September 1979.

113. Bonner, Robert S., and William J. Lentz, "The Visioceilometer: A Portable Cloud Height and Visibility Indicator," ASL-TR-0042, October 1979.

114. Cohn, Stephen L., "The Role of Atmospheric Sulfates in Battlefield Obscurations," ASL-TR-0043, October 1979.

115. Fawbush, E. J., et al, "Characterization of Atmospheric Conditions at the High Energy Laser System Test Facility (HELSTF), White Sands Missile Range, New Mexico, Part I, 24 March to 8 April 1977," ASL-TR-0044, November 1979.

116. Barber, Ted L., "Short-Time Mass Variation in Natural Atmospheric Dust," ASL-TR-0045, November 1979.

117. Low, Richard D. H., "Fog Evolution in the Visible and Infrared Spectral Regions and its Meaning in Optical Modeling," ASL-TR-0046, December 1979.

118. Duncan, Louis D., et al, "The Electro-Optical Systems Atmospheric Effects Library, Volume I: Technical Documentation," ASL-TR-0047, December 1979.

119. Shirkey, R. C., et al, "Interim E-O SAEL, Volume II, Users Manual," ASL-TR-0048, December 1979.

120. Kobayashi, H. K., "Atmospheric Effects on Millimeter Radio Waves," ASL-TR-0049, January 1980.

121. Seagraves, Mary Ann, and Louis D. Duncan, "An Analysis of Transmittances Measured Through Battlefield Dust Clouds," ASL-TR-0050, February 1980.

122. Dickson, David H., and Jon E. Ottesen, "Helicopter Remote Wind Sensor Flight Test," ASL-TR-0051, February 1980.

123. Pinnick, R. G., and S. G. Jennings, "Relationships Between Radiative Properties and Mass Content of Phosphoric Acid, HC, Petroleum Oil, and Sulfuric Acid Military Smokes," ASL-TR-0052, April 1980.

124. Hinds, B. D., and J. B. Gillespie, "Optical Characterization of Atmospheric Particulates on San Nicolas Island, California," ASL-TR-0053, April 1980.

125. Miers, Bruce T., "Precipitation Estimation for Military Hydrology," ASL-TR-0054, April 1980.

126. Stenmark, Ernest B., "Objective Quality Control of Artillery Computer Meteorological Messages," ASL-TR-0055, April 1980.

127. Duncan, Louis D., and Richard D. H. Low, "Bimodal Size Distribution Models for Fogs at Meppen, Germany," ASL-TR-0056, April 1980.

128. Olsen, Robert O., and Jagir S. Randhawa, "The Influence of Atmospheric Dynamics on Ozone and Temperature Structure," ASL-TR-0057, May 1980.

129. Kennedy, Bruce W., et al, "Dusty Infrared Test-II (DIRT-II) Program," ASL-TR-0058, May 1980.

130. Heaps, Melvin G., Robert O. Olsen, Warren Berning, John Cross, and Arthur Gilcrease, "1979 Solar Eclipse, Part I - Atmospheric Sciences Laboratory Field Program Summary," ASL-TR-0059, May 1980

131. Miller, Walter B., "User's Guide for Passive Target Acquisition Program Two (PTAP-2)," ASL-TR-0060, June 1980.

132. Holt, E. H., H. H. Monahan, and E. J. Fawbush, "Atmospheric Data Requirements for Battlefield Obscuration Applications," ASL-TR-0061, June 1980.

133. Shirkey, Richard C., August Miller, George H. Goedecke, and Yugal Behl, "Single Scattering Code AGAUSX: Theory, Applications, Comparisons, and Listing," ASL-TR-0062, July 1980.

134. Sojka, Brian Z., and Kenneth O. White, "Evaluation of Specialized Photoacoustic Absorption Chambers for Near-Millimeter Wave (NMMW) Propagation Measurements," ASL-TR-0063, August 1980.

–8